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【Article】

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Abstract

Countries in the world, especially developing countries, are under pressure to deal with a variety of environmental problems, such as industrial pollution, urban environmental issues, and global warming, while they are expected to simultaneously achieve high economic growth. In this context, they urgently need to leapfrog over environmental difficulties through progressive environmental management, using their "latecomer's advantage" to the maximum extent possible. This study examined whether or not East Asian economies actually enjoy the latecomer's advantage in the area of environmental management, utilizing the analytical framework of the environmental Kuznets curve. The study's main findings are as follows: (1) the time-series EK curves of their economies are consistent with the hypothesis that they do enjoy the latecomer's advantage, and (2) a regression analysis using panel data provides significant confirmation of the existence of the latecomer's advantage for addressing the well known environmental problem of sulfur and carbon emissions.

1. Introduction

Countries around the world presently face two kinds of policy challenges: economic development and environmental conservation. In particular, developing countries in the process of industrialization are under pressure to deal simultaneously with a variety of environmental problems, including industrial pollution, urban environmental issues, the deterioration of ecosystems and global warming, while at the same time being expected to achieve further economic development. In this context, developing countries urgently need to leapfrog over environmental difficulties through progressive environmental management and technology, using their "latecomer's advantage"(1) to the maximum extent possible.

The purpose of this study is to examine whether or not East Asian economies actually do enjoy the latecomer's advantage in the area of environmental management and technology; the analytical framework of the environmental Kuznets curve (EK curve) is used to arrive at a conclusion. The strategic implications of our analyses are significant in terms of international assistance granted in the area of environmental technology and management to help developing countries benefit from the latecomer's advantage. It seems significant to target East Asian economies in this study, because most of them face environmental policy challenges in the midst of industrialization, and because, being at different stages of development, they might be able to make use of the latecomer's advantage, depending on the stage of their development in the area of environmental management and technology.

In the following sections, we will first review previous studies on the EK curve and clarify this article's position in the debate surrounding the EK curve (Section 2), present our own empirical study of the latecomer's advantage (Section 3), and end with concluding remarks (Section 4).

2. Previous Studies and This Article's Position

The EK curve provides an analytical framework for examining how developing countries deal with environmental issues. The hypothesis behind the EK curve is that, in the course of economic development, the environment gets worse before it gets better. At the first stage of industrialization, pollution intensifies rapidly because people are more interested in jobs and income than in clean air and water, communities are too poor to pay for pollution abatement, and environmental regulation is correspondingly weak. The balance shifts as income rises. Leading industrial sectors become cleaner, people value the environment more highly, and regulatory institutions become more effective. Pollution levels off in the middle-income range and falls toward pre-industrial levels in wealthy societies. This dynamic is represented by the EK curve.

2.1 Empirical Testing of the EK Curve and Debates

The issue of the EK curve was first discussed in the World Bank's 1992 World Development Report (World Bank 1992). The report described a cross-sectional EK curve for concentrations of sulfur dioxide. Since the World Bank's report, there have been numerous empirical tests and theoretical debates on the EK curve. Empirical evidence has been accumulating, supporting the validity of the EK curve for some regions and environmental problems. Grossman and Krueger (1995) found an EK-curve relationship between the per capita GDP and urban air quality (the concentration of suspended particulate matter (SPM) and sulfur dioxide (SO_2)), while Selden and Song (1994) discovered the existence of an EK-curve relationship for the aggregate emissions of SPA, SO_2, oxides of nitrogen and carbon monoxide. An EK-curve relationship was also found for fecal coliform bacteria and arsenic in rivers (Islam, 1996). Stokey (1998) made a theoretical contribution to the explanation of the EK curve using dynamic growth models. Suri and Chapman (1998) examined the linkage between the EK curve and the international trading of industrial goods.

Despite these advances, it is prudent to resist the temptation to elevate the EK curve hypothesis to a universal law of development. There is a substantial body of empirical work that contradicts the EK curve hypothesis (Ecological Economics, 1998; Rothman, 1998). In addition, research has been limited to the environmental problems for which data exist, such as the concentration of pollutants in urban areas. We were not aware of any empirical analyses of the relationship between income and the degradation of key ecological services.

2.2 Frontiers of EK-curve Studies: a Time-series Approach

Most of the empirical studies so far have concentrated on validating the EK curve hypothesis and its requirements, using cross-sectional data from developed countries. This cross-sectional approach adopted by most studies might, as Borghesi (1999) argued, be misleading, since environmental degradation is generally increasing in developing countries and decreasing in industrialized ones, and the EK curve within the cross-sectional framework might therefore reflect the mere juxtaposition of two opposite trends rather than describe the evolution of a single economy over time. One of the frontiers of EK-curve studies is the comparative analysis of the EK curves of specific countries in terms of the height and timing of their peaks, their shapes, etc., and the investigation of the causes of different EK-curve patterns, especially external impacts, such as policy changes, technological innovation and technology transfer. To address these issues, the EK curve should be validated in specific countries using time-series data. Irie, et al. (2000) tested the empirical validity of the EK curves of individual countries for SO_2, using relevant time-series data from 30 developed countries (OECD countries and the former Soviet Union). The main findings were that 1) the EK curves were verified for SO_2 emissions in 17 countries, 2) the EK curves varied in the shape of their trajectories and the height and timing of their peaks, and 3) the differences in the height can be explained by five factors: the technology available in the country, the scale of the economy, the quality of the fuel used, the leading industries, and the political system.

This time-series approach has been developed to examine the hypothesis that developing societies, utilizing progressive environmental management and the technology of more advanced countries, might be able to experience an EK curve that is lower and flatter than what the conventional wisdom would suggest; they might be able to develop their economies from low levels of per capita income with little or no degradation in environmental quality, and then at some point experience improvements in both income and environmental quality. Concerning environmental management, Panayotou (1997), formulating a tentative equation for a sample of 30 developed and developing countries for 1982–1994, found that effective policies and institutions can significantly reduce environmental degradation at low income levels and speed up improvements at higher income levels, thereby lowering the EK curves, at least for ambient sulfur dioxide levels. Matsuoka, et al. (2000) compared the EK curves of Asian countries and explained the differences in their height by the dissemination of environmental monitoring systems in Asian countries. As for environmental technology, Martin and Wheeler (1992) argued that, because increased openness to trade tends to lower the price of cleaner imported technologies while increasing the competitive pressure to adopt them, firms in relatively open developing economies adopt cleaner technologies more quickly.

2.3 This Article's Position: Examining the Latecomer's Advantage

In this article, the existence of the latecomer's advantage in the area of environmental management and technology in East Asian economies is verified, by confirming the downward shift of the EK curves of the sample latecomer economies in East Asia. In this context, the analysis strategy is to extend the time-series approach to the above-mentioned review of the EK curve studies. We here define 'the latecomer's advantage' in the area of environmental management and technology in terms of the availability of latecomer economies to integrate progressive know-how, skills and technology, which have already been created by more advanced economies, into their environmental government policies and private activities; latecomer economies are expected not to repeat the mistakes made by developed economies, but to leapfrog over environmental difficulties by absorbing their know-how, skills and technology. International assistance plays an important role in materializing the latecomer's advantage. Since environmental resources are valuable for high-income countries today and for developing countries in the future, a case could be made for the need to provide assistance to developing countries to help them avoid, or at least limit, irreversible environmental damages. In addition, the idea of assistance derives from the observation that production technologies in developed countries are cleaner than those in developing countries, and that a wide range of pollution abatement technologies is available in developed countries. Since most developing countries lack the financial resources to import these technologies at commercially-viable prices, the case has been made that developed countries should transfer these technologies to developing countries on concessionary terms.

Several factual examples of the latecomer's advantage in East Asian economies are as follows. Latecomer economies, such as the ASEAN countries, have incorporated environmental considerations into their development strategies in the earlier stages of their development by learning the lessons of the developed countries. Between the late 1970s and the early 1980s, Indonesia, Malaysia, the Philippines and Thailand began to establish fundamental frameworks for environmental protection, such as laws, standards, and institutions. Indonesia and the Philippines have specified items related to environmental protection in their constitutions (Japanese Environment Agency, 1998), and they have developed their own environmental impact assessment system (Indonesia in 1978, the Philippines in 1993), earlier than Japan did in 1997.(2) In addition to legal and institutional frameworks, they have introduced advanced environmental technologies at various levels of central and local governments and in private companies. For example, in the field of environmental monitoring technology, Matsuoka, et al. (2000) showed that Malaysia, Thailand and Indonesia simultaneously introduced automatic air-monitoring facilities, such as telemeter systems (remote data reporting), during the 1980s and 1990s based on the experiences of industrialized countries. As for industrial technology, Thailand has set up desulfurization equipment in electric power plants in 2001 thanks to Japan's ODA.

One of the counter-arguments to the hypothesis of the latecomer's advantage is the 'race to the bottom' scenario, in which the pressures that global competition places on environmental regulations results in outsourcing or relocation. Dasgupta, et al. (2002) argues that the relatively high environmental standards in high-income economies impose high costs on polluters, and shareholders pressure the firms to relocate to low-income countries, whose people are so eager to get jobs and income that their environmental regulations are weak or nonexistent. The scenario may not shift the latecomers' EK curves downwards; on the contrary, it may even lift them. The point of this analysis, which examines the possibility of a downward shift of the EK curves of latecomer economies, lies in the verification of not only the existence of the latecomer's advantage but also the dominance of the latecomer's advantage over the latecomer's disadvantage resulting from the 'race to the bottom' scenario brought about by globalization.

3. Empirical Studies

We now turn to the empirical studies on whether East Asian economies enjoy the latecomer's advantage in the area of environmental management and technology, within the analytical framework of the environmental Kuznets curve. We focus on eight economies: Japan, Korea, Taiwan, Malaysia, Thailand, the Philippines, Indonesia, and China.(3) Our analysis will comprise two steps. First, we will simply compare the trajectories of the sample economies' EK curves on a time-series basis. Second, we will carry out a regression analysis to identify the latecomer's advantage, using panel data of the sample economies. Throughout this analysis, we focus on sulfur and carbon emissions as indices of environmental degradation, because they are often used to represent environmental quality and the data are generally available.

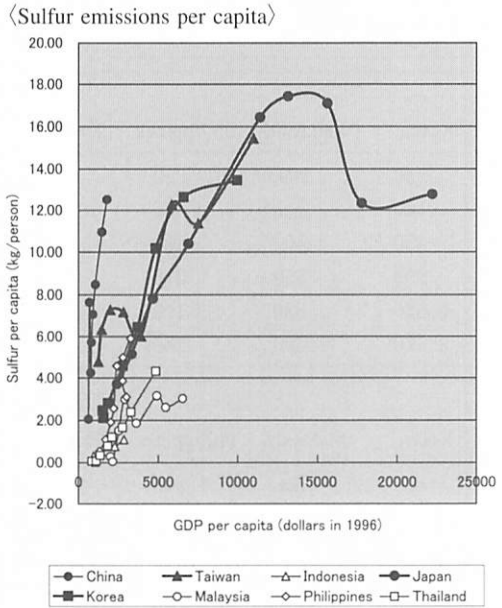
3.1 Comparison of EK Curves

We will first compare the time-series EK curves of the sample East Asian economies for the second half of the past century (1950–2000). We will use the per capita sulfur and carbon emissions as indices of environmental degradation[4] and the per capita real GDP as the index of income.

3.1.1 Data

For the sulfur emissions, we will use the data estimated by Lefohn et al. (1999). This database was developed for the purpose of estimating the global emissions of sulfur from 1850 to 1990, with a common methodology applied across all years and countries. In all cases, the emissions estimates for each country are based on the production, percent sulfur, and sulfur retention information associated with that country's activities. For the carbon emissions, we will use the data estimated by Marland et al. (2003). The database, named "Global, Regional, and National Fossil Fuel CO_2 Emissions," covers data from 1751 to 2000. The emissions estimates are based on a specific methodology using statistics on gas fuels, liquid fuels, solid fuels, gas flaring, cement manufacturing, and estimated parameters of carbon coefficients and oxidation rates. For the population and the real GDP per capita, we will use Version 6.1 of the Penn World Tables (PWT), estimated by Heston et al. (2002). As the per capita real GDP, we will use the time-series data of "REAL GDP PER CAPITA (CONSTANT PRICE: LASPEYRES)" in 1996 US dollar prices. The database covers data from 1950 to 2000. The availability of the data for the sample economies is described in the Appendix.

〈Sulfur emissions per capita〉



〈Carbon emissions per capita〉

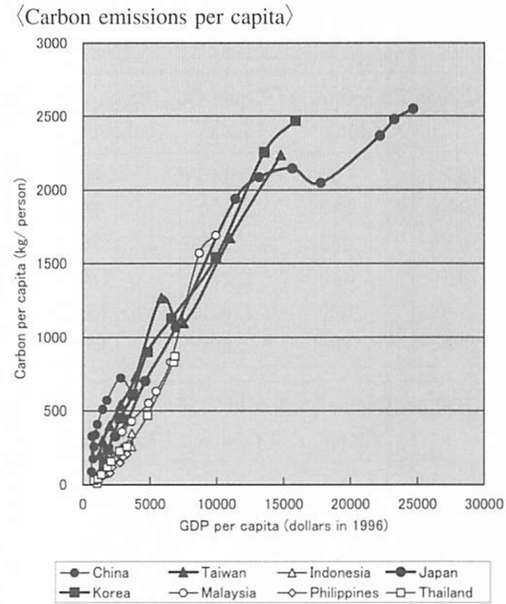


Figure 1. Income-Environment Relationships in East-Asia Economies

Sources: Lefohn A.S., J.D. Husar, and R.B. Husar (1999)
Heston Alan, Robert Summers and Bettina Aten (2002)

Sources: Marland, G., T.A. Boden, and R.J. Andres (2003)
Heston Alan, Robert Summers and Bettina Aten (2002)

3.1.2 Main Findings

Figure 1 and Table 1 describe the relationships between the sulfur and carbon emissions per capita and the real GDP per capita in the eight sample economies for 1950–2000. Figure 1 and Table 1 reveals the followings facts.

Regarding the shapes of the EK-curve trajectories of the sample economies, it is only in the case of sulfur emissions in Japan that the inverted U-shapes of the EK curves are clearly defined. Other instances suggest that the economies may remain in the positively-sloping part of the EK curve. The slopes, however, have recently begun to flatten in relatively advanced economies: Japan for carbon emissions, and Korea and Malaysia for sulfur and carbon emissions.(5)

Regarding the locations in the EK-curve trajectories of the sample economies, Japan, which is the most advanced country, and Korea and Taiwan, which are newly industrializing economies, are in almost the same location in their trajectories for both environmental indices. Indonesia, Malaysia, the Philippines and Thailand, all of which belong to the Association of Southeast Asian Nations (ASEAN), are

Table 1. Income-Environment Relationships in East-Asia Economies

⟨Sulfur Emissions per Capita (kg/person)⟩

	China	Taiwan	Indonesia	Japan	Korea	Malaysia	Philippines	Thailand
1950	n.a.	n.a.	n.a.	3.71	n.a.	n.a.	0.54	0.01
1960	7.64	6.33	0.32	7.82	2.12	0.05	1.91	0.08
1970	5.71	7.18	0.19	16.43	4.58	2.99	4.57	0.80
1980	8.49	12.28	0.78	17.10	10.18	3.15	5.90	1.66
1990	12.52	15.44	1.09	12.78	13.46	3.02	3.09	4.32

⟨Carbon Emissions per Capita (kg/person)⟩

	China	Taiwan	Indonesia	Japan	Korea	Malaysia	Philippines	Thailand
1950	40	140	30	330	30	n.a.	50	10
1960	330	300	60	700	140	n.a.	80	40
1970	260	540	70	1,940	450	360	180	120
1980	410	1,270	170	2,150	900	550	210	230
1990	570	1,670	250	2,370	1,540	830	190	470
2000	600	2,680	350	2,550	2,470	1,690	280	870

⟨GDP per Capita (dollars in 1996)⟩

	China	Taiwan	Indonesia	Japan	Korea	Malaysia	Philippines	Thailand
1950	n.a.	n.a.	n.a.	2,417	n.a.	n.a.	1,345	1,071
1960	685	1,468	960	4,657	1,571	2,147	2,022	1,121
1970	820	2,809	1,097	11,396	2,777	2,910	2,401	1,836
1980	1,072	5,850	1,891	15,631	4,830	4,905	3,275	2,756
1990	1,790	10,995	2,851	22,194	9,959	6,540	3,007	4,838
2000	3,747	n.a.	3,637	24,672	15,881	9,937	3,424	6,857

Sources: Lefohn A.S., J.D. Husar, and R.B. Husar (1999)
Marland, G., T.A. Boden, and R.J. Andres (2003)
Heston Alan, Robert Summers, and Bettina Aten (2002)

in lower locations for both environmental indices than Japan, Korea and Taiwan (but the Philippines are not lower in some parts of their trajectory for sulfur emissions, and Malaysia is not lower in its recent trajectory for carbon emissions). China has the highest trajectory for both environmental indices. This observation is consistent with the hypothesis that the ASEAN sample economies benefit from the latecomer's advantage; they have employed better environmental technology and management than Japan, Korea, and Taiwan in their earlier stages of development. China's trajectory may reflect its peculiar economic structure, characterized by a heavy dependence on coal as an energy source.

3.2 Regression Analysis of the Latecomer's Advantage

Now, we will conduct a regression analysis to identify the latecomer's advantage in the East Asian sample economies. We have already recognized the possibility of the existence of the latecomer's advantage by showing the differences in the locations of the sample economies along the EK-curve trajectories (see Section 3. 1). It seems, however, that the differences in the EK-curve locations may be due to other country-specific factors, such as the structure of the energy sources, rather than the latecomer's advantage. It is therefore necessary to verify the existence of the latecomer's advantage through statistical regression of analysis of the panel data of the sample economies.

3.2.1 Methodology and Data

We will first clarify some methodological points related to our analysis. To study the relationship between pollution and growth, there are two possible approaches to model construction. One is to estimate a reduced-form equation that relates the level of pollution to the level of income. The other is to model the structural equations relating environmental regulations, technology, and industrial composition to GDP, and then to link the level of pollution to the regulations, technology and industrial composition. We here take the reduced-form approach for the following reasons. First, the reduced-form estimates give us the net effect of a nation's income on pollution. If the structural equations were to be estimated first, one would need to solve back to find the net effect, and confidence in the implied estimates would depend on the precision and potential biases of the estimates at every stage. Second, the reduced-form approach spares us from having to collect data on pollution regulations and the state of the existent technology, which are not always available. Although a reduced-form relationship gives no indication of the direction of causality, namely whether growth affects the environment or the other way around, we think that the reduced-form relationship between pollution and income is an important first step.(6) We then specify the reduced-form equation in accordance with our analytical interests. Our specific concern regarding the EK curves for the sample economies is whether the EK-curve trajectories have shifted downwards as a result of the latecomer's advantage, in other words, whether the levels of environmental pollution have been affected not only by the levels of per capita income following the EK curve, but also by the speed of development of the latecomer economies. If the later a sample economy reaches a certain level of development, the lower its environmental pollutants, then we speculate that the economy does not repeat the EK-curve trajectories already experienced by the developed economies, but leapfrog over the environmental difficulties by absorbing their know-how, skills and technology. We also hypothesize guess that, even though the economy may suffer from the disadvantage caused by the 'race to the bottom' scenario brought about by globalization, the latecomer's advantage does surpass the disadvantage. Therefore, we will include a term representing the speed of development of the latecomers into the ordinary regression model of the EK curve, and specify the modified model as follows.

$$[SOP_{it}, COP_{it}] = a_0 + a_1 YRP_{it} + a_2 YRP^2_{it} + a_3 YEAR_{it} + a_4 COAL_{it} + e_{it} \quad (1)$$

where i is the country index, t is the time index, and e is the error term. The dependent variables SOP and COP are measures of environmental pollutions: SOP is for the sulfur emission per capita, and COP is the carbon emission per capita. As for the independent variables, YRP is the real GDP per capita, YEAR is the year when the data were collected and represents the speed of development of the latecomers, and COAL is the share of electricity produced from coal out of the country's total electricity production. In order to estimate a, we must construct a table of the annual environmental and economic data from the eight economies for 1950 to 2000. The data for sulfur and carbon emissions, the population and the real GDP per capita come from Lefohn et al. (1999), Marland et al. (2003), and Heston et al. (2002), respectively, as mentioned in Section 3.1.1. The data for the electricity production from coal come from the World Bank (2002). Their availability is described in the Appendix.[7]

In order to verify the inverted U-shapes of the EK curves, the signs and magnitudes of a_1 and a_2 should be examined. Environmental pollutants can be said to exhibit a meaningful EK curve with the real GDP per capita, if $a_1>0$ and $a_2<0$, and if the turning point, $-a_1/2a_2$ is a reasonably low number. Of particular importance is the coefficient of YEAR, a_3, which is useful for identifying the existence of the latecomer's advantage. The sign of a_3 is expected to be negative, because the latecomer's advantage tells us that the later a sample economy reaches a certain level of development, the lower its environmental pollutants. The sign of the coefficient of COAL, a_4, is expected to be positive, because higher dependence on coal for electricity production would produce heavier emissions of sulfur and carbon.

Apart from the real GDP per capita, the speed of development of the latecomers and the structure of their energy sources, there are also likely to be exogenous factors that affect emissions. For instance, climate, geography, and energy resources vary widely among countries and may well be correlated with emissions. Insofar as these factors cause the error term e to be correlated among countries for a given period, pooled cross-section estimates that ignore this correlation will be inefficient. To address this issue, we must specify an error-components model, in which:

$$e_{it} = r_i + u_{it} \quad (2)$$

where r_i is the country effect, and u_{it} is the remaining error term. In choosing between fixed-effects and random-effects estimation, an important issue is whether the country effect is correlated with the explanatory variables. In the absence of such a correlation, random-effects estimation is consistent and efficient. In contrast, if such a correlation exists, there may be omitted-variable bias, necessitating fixed-effects estimation. We here use fixed-effects estimation, since the statistics of the Wu-Hausman test (Hausman 1978) used to help choose between these two approaches argue in favor of fixed-effects estimation (see Table 2).

Table 2. Summary of the Wu-Hausman Test

Test cross-section random effects in case of SOP

Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
22.75	4	0.0001

Test cross-section random effects in case of COP

Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
20.42	4	0.0004

3.2.2 Estimation Results and Main Findings

Table 3 lists the results of the fixed-effects estimation of the sulfur and carbon emissions. First, we must verify the inverted U-shapes in the EK curves of each emission index. All the estimates for the coefficients a_1 and a_2, have the expected signs, and are different from zero as high levels of significance, and the turning points indicate feasible numbers. The indices for the sulfur and carbon emissions can, therefore, be said to reflect a meaningful, inverted U-shaped EK curve with the real GDP per capita. Allthough it is only in the case of sulfur emissions in Japan that the inverted U-shapes is clearly observed, as mentioned in the previous section, the estimation results support the inverted U-shapes of the EK curves of each emission index. The reason for this seems to be that the estimation results reflect all of the information, including the flattened slopes of the panel data of the eight sample economies.

Second, we must verify the existence of the latecomer's advantage. All of the estimates for the coefficients of YEAR, a_3, are negative and discernable. Therefore it can be said that the existence of the latecomer's advantage might be reflected in the sulfur and carbon emissions of the sample economies.

Third, the effect of the structure of the energy sources on the emissions must be elucidated. The estimates for the coefficient of COAL, a_4, are not significantly positive for either the sulfur or the carbon emissions. We verified by the multicollinearity coefficient that COAL and two other explanatory variables, YRP and YEAR, are linearly dependent, and therefore we omitted COAL from the estimations. The omission of COAL, however, does not affect the estimation results pertaining to the verification of the inverted U-shapes of the EK curves and the verification of the existence of the latecomer's advantage.

Table 3. Estimation Results for Sulfur and Carbon Emissions

(Fixed Effects Estimation)

Variales	SOP		COP	
Const.	$2.39*10^2$	$6.61*10$	$7.99*10^3$	$7.52*10^3$
YRP	$2.93*10^{-3}$*** (16.78)	$2.49*10^{-3}$*** (20.92)	$2.28*10^{-1}$*** (23.91)	$2.32*10^{-1}$*** (36.33)
YRP^2	$-9.70*10^{-8}$*** (−15.33)	$-8.50*10^{-8}$*** (−16.98)	$-4.54*10^{-6}$*** (−13.86)	$-4.62*10^{-6}$*** (−18.66)
YEAR	$-1.23*10^{-1}$*** (−4.66)	$-3.45*10^{-2}$*** (−3.23)	$-4.16*10^{0}$*** (−3.04)	$-3.94*10^{0}$*** (−8.31)
COAL	$-7.30*10^{-3}$ (−0.72)		$9.00*10^{-2}$ (0.09)	
Adj R**2	0.92	0.93	0.96	0.97
Turning Point	$1.51*10^4$	$1.46*10^4$	$2.51*10^4$	$2.51*10^4$

Note:

a) The T-value is shown in parenthese.
   One, two, or three asterisks indicate that a coefficient estimate is significantly different from zero at 10, 5, or 1% percent level, respectively.

b) Constant terms for fixed-effect model indicate the mean of the estimated country effects.

Sources: Lefohn A.S., J.D. Husar, and R.B. Husar (1999)
Marland, G., T.A. Boden, and R.J. Andres (2003)
Heston Alan, Robert Summers, and Bettina Aten (2002)
World Bank (2002)

Appendix Data Availability for Table 1 and Table 2

Variables	Contents	Units	Availability in 1950–2000	Sources
SOP	sulfur emissions per capita	kg/person	1952–1990 〈C〉 1951–1990 〈W〉 1960–1990 〈I〉 1950–1990 〈J, P, T〉 1953–1990 〈K〉 1955–1990 〈M〉	I, III
COP	carbon emissions per capita	kg/person	1950–1990 〈C, W, I, J, K, P, T〉 1970–1990 〈M〉	II
YRP	real GDP per capita (dollars in 1996)	dollars/person	1952–2000 〈C〉 1951–1998 〈W〉 1960–2000 〈I〉 1950–2000 〈J, P, T〉 1953–2000 〈K〉 1955–2000 〈M〉	III
YEAR	year of the data	19**–2000	1950–2000	
COAL	electricity production from coal sources	% of total	1971–1999 〈C, K, P, T〉 n.a. 〈W〉 1985–1999 〈I〉 1960–1999 〈J〉 1988–1999 〈M〉	IV

Note:

1) The alphabets in 〈 〉 of the Availability item show the following countries and economy.
C: China, W: Taiwan, I: Indonesia, J: Japan, K: Korea, M: Malaysia, P: Philippines, T: Thailand

2) The numbers in the Sources item indicate the following data sources.
I : Lefohn A.S., J.D. Husar, and R.B. Husar (1999)
II : Marland, G., T.A. Boden, and R.J. Andres (2003)
III: Heston Alan, Robert Summers, and Bettina Aten (2002)
IV: World Bank (2002)

4. Concluding Remarks

In this study we set out to examine, using empirical techniques (Section 3), whether or not East Asian economies enjoy the latecomer's advantage in the area of environmental management and technology.

First, we concentrated on a comparative analysis of the EK curves of the sample East Asian economies. We found that the differences in the locations along the EK-curve trajectories for sulfur and carbon emissions among the sample economies are mostly consistent with the hypothesis that they benefit from the latecomer's advantage in the area of environmental management and technology. Nevertheless, the survey cannot be considered a direct proof of the existence of the latecomer's advantage. Therefore, as a second step we carried out a regression analysis to verify the latecomer's advantage using panel data for the sample economies. Through this analysis, we verified the existence of the latecomer's advantage on the well-known environmental issue of sulfur and carbon emissions. We speculate that advanced countries such as Japan addressed the problem of sulfur and carbon emissions early on, by regulating the emissions and developing technologies to mitigate them, and that latecomers such as the ASEAN countries seem to be in a position to benefit from the transfer of environmental know-how and technologies from advanced countries that already possess them.

However, this study may only be an initial step in the analysis of the latecomer's advantage. Analytical issues still remain that need to be addressed. First, environmental degradation involves a wide variety of pollutants and ecosystems, and therefore the empirical testing of emissions and factors other than sulfur and carbon is needed. Second, we can enrich the corroborative information on the latecomer's advantage by showing how and in what fields the transfers of technology and know-how to developing countries have been carried out. Further studies on the environmental Kuznets curve will provide significant information, enabling the improved planning and evaluation of environmental assistance to developing countries.

Notes

(1) The hypothesis of the "latecomer's advantage" was advanced by Alexander Gerschenkron. See Gerschenkron (1962).

(2) The efforts in the area of environmental management of ASEAN countries have not always led to successful performances, because they have often lacked the capacity to enforce environmental laws and standards, and to disseminate new technologies nationwide. Developed countries, therefore, have focused their assistance since the 1980s on capacity building in the area of environmental management.

(3) Hong Kong and Singapore were excluded because in the context of this study they behave more like big cities, and also because of the difficulty in comparing them with other countries in terms of per capita environmental pollution. Taiwan was excluded in the case of sulfur emissions because of data constraints.

(4) Hayami (1997) uses CO_2 emission *per $100 GNP* as an index of environment degradation in his EK-curve analysis of carbon emission, whereas most of other studies use emissions *per capita* as an environmental index. This article simply adopts emissions *per capita* as an orthodox index of environment degradation.

(5) Iwami (2001) describes the experience of environmental management in East Asian economies. He states that the remarkable improvement of sulfur emissions in Japan for the period from the beginning of 1970s to the half of 1980s comes from environmental regulations reinforced by central and local government, and technological development for desulfurization and energy efficiency promoted by private companies. He also states that the other East Asian economies are trying to make the same kinds of efforts as Japan did.

(6) Grossman and Krueger (1995), and Selden and Song (1994), which we introduced in reviewing previous studies, also estimate a reduced-formed equation.

(7) As shown in Appendix, the data for electricity production from coal are not available for Taiwan. Therefore, Taiwan is excluded from the estimation in Section 3. 2.

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